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INFLATABLE BOAT STANDARD DEVELOPMENT

COAST GUARD RESEARCH AND DEVELOPMENT CENTER

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16. Abstract <p style="text-align: center;">The Federal Boat Safety Act of 1971 establishes boating standards for most monohull boats under 20' in length. The safety standards specifically exclude sailboats, canoes, kayaks and inflatable boats. Commandant (G-DST-2) ltr 735200 Ser 0061 of 12 Dec 72 authorized the Coast Guard Research and Development Center, Groton, Connecticut, to conduct an evaluation of inflatable boats in support of the development of a safety standard. This report contains the data collected and procedures developed in the areas of construction, safe loading, powering and underway stability, and human factors. Recommended standards concepts are proposed.</p> <p style="text-align: center; font-size: small;">NATIONAL TECHNICAL INFORMATION SERVICE P.O. Department of Commerce Springfield, VA 22151</p>			
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1.0 INTRODUCTION

The Federal Boat Safety Act of 1971 authorized the Coast Guard to establish Boating Safety Standards. The safety standards specifically exclude sailboats, canoes, kayaks, and inflatable boats. In order to establish safety standards for inflatable boats, it was necessary to gain some background knowledge of inflatables. Important areas of interest are construction, safe loading, powering and underway stability.

Both British Standards Institution ¹ and the French Naval Engineering and Industries Pleasure Navigation ² have specifications for inflatable boats. These specifications specify material requirements as well as operational guidelines and performance standards. The American Boat and Yacht Council, Inc., Hull Performance Committee is also developing an inflatable boat standard.³ These were used as guidelines and were an important source of background information.

To obtain experimental data, an inflatable boat test program was initiated at the Coast Guard Research and Development Center, Groton, Connecticut. The test program was designed to establish procedures for evaluating inflatable boats and to identify any specific problems in the above mentioned areas of interest.

The purpose of this report is to document the test procedures developed at the R&D Center in the areas of construction, safe loading, powering and underway stability, and to identify the problems affecting the safety of inflatable boats. Recommended standards concepts are proposed.

2.0 STATE OF ART SURVEY

2.1 Objective

The objective of this task was to identify the inflatable boats available to the boating public and to identify specific models to be procured for evaluation in the test program.

2.2 Market Definition

A description of available inflatable boats was compiled from information contained in sales brochures. Sixteen manufacturers and/or importers were included. There are three basic inflatable boat configurations:

2.2.1 Canoe-shaped inflatables, having a high length/beam ratio and utilizing paddles for propulsion. Of 180 boats listed 19, or 10.6%, were canoes.

2.2.2 Dinghy-type inflatables, having a low length/beam ratio and buoyancy tubes completely surrounding the passenger compartment. They are intended to be rowed or paddled, but several models can be fitted with brackets for low-powered (less than 7.5 hp) outboards. Of 180 boats listed 89, or 49.4%, were dinghies.

2.2.3 Sportboat inflatables, having U-shaped buoyancy tubes connected to a plywood transom and a low length/beam ratio. These boats are intended to be powered by outboards (up to 115 hp), but most models also come equipped with oars and oarlocks. They usually have some sort of inflatable or wooden keel to give the bottom a V-shape. Some models have a rigid fiber glass V-hull bonded to the buoyancy tubes. Of 180 boats listed, 72, or 40.0%, are sportboats.

There are two basic construction techniques being used in inflatable boat manufacture:

2.2.4 Unsupported vinyl boats usually are made from a polyvinylchloride based material. Electronically welded seams are generally used for fabrication. This type of material is used primarily in the construction of relatively inexpensive canoe and dinghy-type inflatables. Boats made of this material utilize low inflation pressures (less than 1.0 psig.) and are propelled primarily by oars or paddles. Some models can be fitted with brackets for use with very low-powered outboards (less than 3hp). Of 180 boats listed, 41.7% use this type of construction, all of which are dinghies or canoes.

2.2.5 Coated fabric boats, made from a nylon or canvas fabric coated with neoprene, hypalon, rubber, a vinyl derivative, or a combination of these materials. Boats are generally fabricated using a cold bonding process, although some models are hot vulcanized. All of the sportsboats and higher powered dinghies utilize a fabric reinforced material. Coated fabric boats generally have inflation pressures of 2.0 - 4.0 psig depending on their intended use. Of 180 boats listed, 58.3% use this type of construction.

Further background information concerning the construction and usage of inflatables was obtained from prior Coast Guard evaluations, available current standards and trips to and/or discussions with inflatable boat manufacturers.



CANOE TYPE
INFLATABLE



DINGHY TYPE
INFLATABLE



SPORTBOAT TYPE
INFLATABLE

FIGURE 1 - CATEGORIES OF INFLATABLE BOATS

2.3 Sample Definition

Four basic guidelines were used in choosing the test fleet.

2.3.1 The test boats should be representative of the market;

2.3.2 Boats having unique features should be evaluated;

2.3.3 Each manufacturer should be sampled in order to get a large cross section of boat configurations and construction techniques;

2.3.4 The size of the fleet should be kept small because of cost considerations and the available time for testing.

Thirteen boats from nine different manufacturers were chosen for evaluation. Samples of each configuration and most of the construction techniques were included. A general description of the test fleet follows:

2.3.5 Canoes. Only one boat of PVC construction was chosen since this group was rather limited in size.

2.3.6 Dinghies. Four boats were chosen from this group. The smallest was a 7'5" long PVC dinghy, and the largest was a 12'8" long coated fabric dinghy with a detachable outboard motor bracket. Four different manufacturers were represented.

2.3.7 Sport boats. Eight boats were chosen from this group. The smallest was 9'3" long and rated for 10 hp. The largest was 16'6" long and rated for 65 hp. All the boats were constructed of coated nylon with glued seams. Six different manufacturers were represented.

Coast Guard ID Number	Adv. * Length	Adv. Beam	Adv. HP Capacity	Adv. Weight Capacity (lbs)	Adv. Persons Capacity	Hull Material
73-01	10'6"	4'10"	25	900	4	Coated nylon
73-02	8'0"	4'0"	3	500	3	Coated nylon
73-03	7'5"	4'3"	N/I	N/I	3	PVC
73-04	11'0"	2'10"	N/I	550	2	PVC
73-05	14'1"	6'1"	55	2205	8	Coated nylon
73-06	12'8"	4'10"	7.5	1093	5	Coated nylon
73-07	14'0"	6'2"	40	1226	6	Coated nylon
73-08	12'0"	5'7"	30	1005	5	Coated nylon
73-09	12'6"	5'6"	45	1100	6	Coated nylon
73-10	9'3"	4'9"	10	N/I	4	Coated nylon
73-11	8'2"	4'2"	5	N/I	5	Coated nylon
73-12	10'4"	4'10"	18	992	N/I	Coated nylon
73-13	16'6"	6'10"	65	2000	10	Coated nylon

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* ADV - as advertised in manufacturer's brochure
N/I - not indicated

Figure 2 - LIST OF INFLATABLE TEST BOATS

3.0 POWERING & UNDERWAY STABILITY

3.1 Objective

The objective of this task was to evaluate the performance of inflatable boats and to establish and/or evaluate approaches to the determination of safe powering.

3.2 Boat Familiarization

Since prior experience with inflatable boats was minimal, the boats were operated under varying weather, load and powering conditions in order to develop a "feel" for inflatables. Several observations were made:

3.2.1 Sportboats - Inflatable sportboats were generally very quick with the manufacturer's rated horsepower. The boats had a light feeling and reacted quickly to changes in thrust direction. They have a tendency to slide rather than turn. All the boats assumed a severe trim angle when power was suddenly applied while the boats were in the displacement mode. Some of the boats were operated in a loaded condition in various weather conditions and on varying headings. The load consisted of two to four passengers (depending on boat size), two tanks of fuel, life jackets, an anchor, and paddles. The loaded boats seemed to handle slightly better. This was attributed to the fact that they were going slower with the increased load.

When power is cut quickly and the sportboats come off plane, the wake enters the boat over the transom. Since these boats have no self-bailing wells, the water comes directly into the passenger area. While this makes the passenger area wet, it is not considered hazardous because of the relatively small amount of water coming on board. Most of the sportboats back down poorly, with little directional control. It should be noted that section 8.5 of the British specification describes subjective tests intended to evaluate these facets of inflatable boat behavior.

3.2.2 Dinghies - Dinghy-type inflatables with detachable motor mounts could not absorb the thrust of the manufacturers' rated outboards. This was caused by one or a combination of several of the following deficiencies.

3.2.2.1 The motor brackets were not securely fastened to the buoyancy tubes. The weight and thrust of the rated outboards cause the brackets to slip and slowly lower the bracket/outboard assembly into the water.

3.2.2.2 The boats did not have sufficient rigidity. Since most of the outboard brackets were not designed to distribute the thrust of the outboards, the concentrated thrust caused the buoyancy tubes to bend under the boat. This resulted in an awkward trim condition and the bent tubes caused the motor to be lowered into the water.



73-01



73-01

FIGURE 3 - POWERING OF INFLATABLE BOATS

3.2.2.3 The boats were too small to carry the weight of an outboard. The smaller dinghies, when fitted with an outboard and a passenger sitting far enough aft to operate the motor, had excessive trim by the stern. In one case, this amount of trim submerged the exhaust ports of the outboard, causing the motor to stall repeatedly.

3.2.3 Manual Propulsion - Most of the boats, although fitted with oars and oarlocks, were unsuited for rowing. Since the boats were so light and float on rather than in the water, they were easily blown about by the wind. One 8' boat could not be paddled by two men in winds as little as 10 knots.

3.3 SUBJECTIVE MAXIMUM HORSEPOWER EVALUATION

The inflatable boats ability to handle horsepower was evaluated subjectively by R&DC personnel. Three factors were considered when subjectively evaluating a boat: maneuverability, underway stability and structural soundness. Maneuverability is defined as boat behavior in transient conditions. This included handling in turns, backing ability and ability to take full throttle accelerations. Underway stability is defined as behavior under steady state (constant velocity) conditions. This included roll, yaw and pitch stability while operating at constant speeds on given headings. Structural soundness is defined as the ability of the boat hull and transom to handle the weight and thrust of the outboard being tested.

Figure 4 lists the assigned subjective maximum horsepowers and give a description of each boat's behavior during evaluation. Figure 5 is a plot of the sportboat subjective horsepowers. The table below is a summary of subjective horsepower ratings for inflatable dinghies.

COAST GUARD ID NUMBER	LENGTH	MANUFACTURER'S RATED HP	SUBJECTIVE HP
73-02	8'0"	3	4
73-06	12'8"	7.5	4
73-11	8'2"	5	4

COAST GUARD ID NUMBER	MANUFACTURER'S RATED HP	SUBJECTIVE HP	LxB FACTOR	COMMENTS
73-01	25	15	50.5	When powered with 25 hp (9"x10", 3 bladed prop) and 18 hp (9 1/4" x 12", 2 bladed prop) there was a pronounced tendency for the boat to yaw violently at top speed. There was less of a tendency toward yaw oscillations with an 18 hp outboard fitted with a standard propeller (9" x 10", 3 bladed). The boat was sluggish and slow with a 9 1/2 hp outboard. It is estimated that 15 hp would be the maximum power that would not cause the boat to yaw.
73-02	3	4	32.0	Boat was operated with 2,4 and 6 hp outboards. While boat performed satisfactory with 6 hp outboard, motor weight and thrust caused trim by the stern and buoyancy tube bend to the point where the motor was almost in the water. The 4 hp outboard caused some bending and trim, but this was not excessive. The detachable outboard motor bracket would not stay on the boat when the maximum reverse thrust of the 2,4 or 6 hp motor was applied.
73-05	55	50	85.6	This boat has been operated extensively with a 40 hp outboard (10 3/8" x 14", 3 bladed prop). The boat is fast, but handles very well. The boat has been powered briefly by a long shaft 50 hp outboard (13 3/4" x 15", 3 bladed prop) and has performed well (manufacturer recommends short shaft engine).

FIGURE 4 - RESULTS OF SUBJECTIVE HORSEPOWER EVALUATION

COAST GUARD ID NUMBER	MANUFACTURER'S RATED HP	SUBJECTIVE HP	LxB FACTOR	COMMENTS
73-06	7.5	4	61.2	Boat was operated with 4 and 6 HP outboards. The buoyancy tubes are extremely limber and motor bracket has a tendency to slip. The weight and thrust of the 6 HP motor causes it to be lowered toward the water, almost to the point of submerging the powerhead. 4 HP is the maximum power that the bracket and limber buoyancy tubes can handle. From a handling and maneuverability standpoint the boat is underpowered with 4 HP. The bracket remains attached to the boat when reverse thrust is applied.
73-07	40	35	78.3	When powered with 40 HP (10 3/8" x 14", 3 bladed prop) outboard, this boat is fast and handles well. However the weight and thrust of a 40 HP outboard causes the transom to deflect. In a chop, this limber transom, combined with the limber buoyancy tubes, cause the motor to oscillate. This oscillation makes the motor difficult to control. This movement has caused the transom to take on a permanent 3/4" deflection at the midpoint of its 50" span. Therefore, while the boat handles well with 40 HP, its maximum allowable horsepower should be downrated for structural reasons.
73-08	30	25	61.5	This boat has been operated extensively with a 25 HP (9" x 10", 3 bladed prop) outboard. It handles and performs exceptionally well. It is felt that the boat could handle slightly more power than 25 HP, but since the transom construction is similar to 73-07 the weight and thrust of a 40 HP outboard would be too great.

FIGURE 4 (Continued)

COAST GUARD ID NUMBER	MANUFACTURERS RATED HP	SUBJECTIVE HP	LxB FACTOR	COMMENTS
73-09	45	35	70.2	Boat was operated with 40 HP (10 3/8" x 14", 3 bladed prop) and 25 HP (9" x 10", 3 bladed prop) outboards. With the 40 HP outboard there was a tendency toward yaw instabilities in a chop. The yaw was minimal, but present. The boat was nicely balanced with 25 HP, but this was definitely not the maximum horsepower that the boat could handle.
73-10	10	7.5/10	44.2	Without optional keel, boat slides excessively in turns. There is no tendency to yaw, roll or flip. Turning ability is so poor, however, that with this configuration a maximum HP of approximately 7.5 would be acceptable in order to keep the boat below planing speeds. With the optional keel, handling improves markedly, but the boat still will not negotiate an ABYC avoidance course. In view of the low level of performance and overall safety of the boat, 10 HP is an acceptable maximum.
73-11	5	4	34.0	Operated boat with 2, 4 and 6 HP outboards. Weight and thrust of 6 HP O/B caused severe trim by the stern and came close to submerging the engine powerhead. Boat performance and maneuverability were acceptable. The 4 HP outboard gave almost the same level of performance, but minimized the trim problems. Reverse thrust of 2, 4 or 6 HP outboard caused a folding of the boat's transom.

FIGURE 4 (Continued)

COAST GUARD ID NUMBER	MANUFACTURER'S RATED HP	SUBJECTIVE HP	LxB FACTOR	COMMENTS
73-12	18	15	49.9	When powered with 18 hp outboard (9" x 10" 3 blade or 9 1/4" x 12" 2 blade props) there was a tendency for the boat to yaw severely, even in calm water. When powered with 9.8 hp the boat behaved well, but speed dropped slightly in turns. Since yaw only takes place at maximum throttle settings (18 hp outboard), it is felt that 15 hp would be an acceptable maximum power.
73-13 12	65	---	115.5	With 40 hp the boat performs well and handles nicely. The transom can take the weight and thrust of the 40 hp outboard.

FIGURE 4 (Continued)

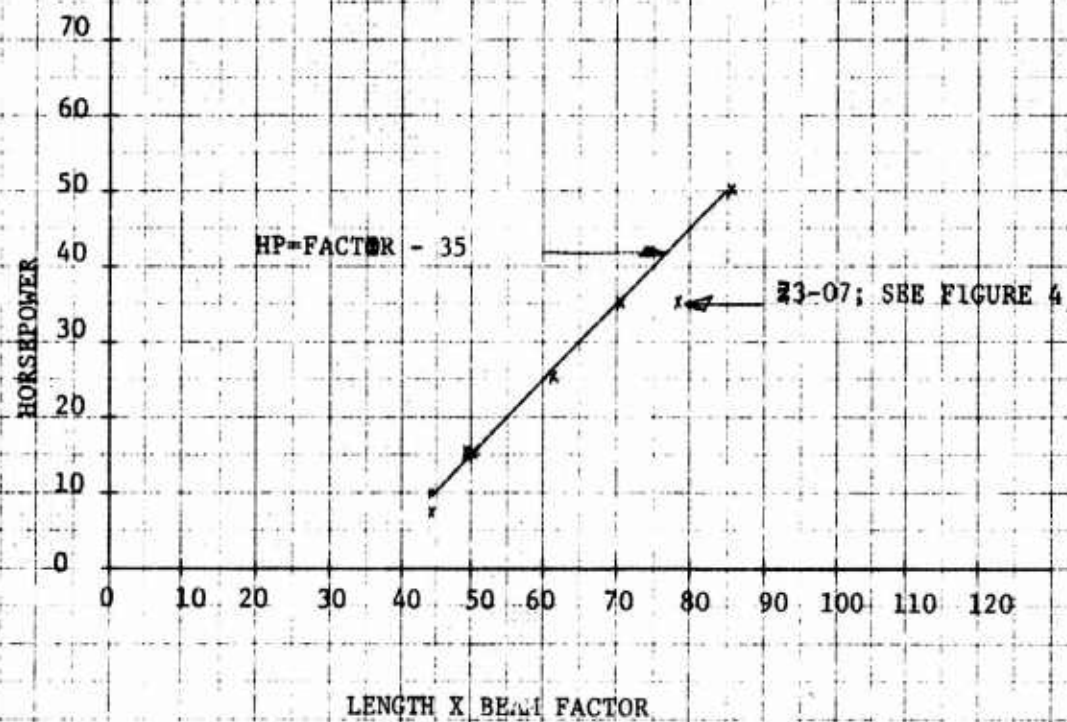


FIGURE 5 - PLOT OF SUBJECTIVE HORSEPOWER vs. LENGTH/BEAM FACTOR FOR INFLATABLE SPORTBOATS

3.4 ABYC AVOIDANCE COURSE

Sportboats were evaluated on the American Boat and Yacht Council avoidance course (figure 6). Dinghies were not tested on the ABYC course since they operate at a low level of speed where maneuverability should not be a problem.

This avoidance course was selected for evaluating the inflatable boats because it is a course which is recognized and understood by the boating industry.

The following conditions from the ABYC handbook, Safety Standards for Small Crafts, define an acceptable performance on the avoidance course:

- a. A minimum of three consecutive runs at continuous full throttle in each direction should be made through the test course passing outside the avoidance marker designated for the determined maximum boat speed without contact with any of the course markers.
- b. There shall be no change of position of any on board equipment or personnel during these runs.
- c. There should be no propeller cavitation while negotiating the course, to the extent there is loss of directional control by the operator. Planning Boats dropping below planning speed....will not be acceptable.
- d. There should be no instability evidenced by oscillating motion in the roll or yaw axes exhibited while negotiating the course.

Top speeds were obtained by timing the boats over a measured distance on the course. Generally, three two-way timing runs were made. The results of these powering tests are presented in figure 7. Figure 8 is a plot of ABYC horsepower as a function of length/beam factor. The subjective HP=FACTOR - 35 line is included for reference. There is generally good agreement between the ABYC course results and the subjective horsepower ratings.

SPEED M.P.H.

18-22.5

22.5-27.5

27.5-32.5

32.5-35

The diagram illustrates an ABYC Test Course layout. It features a central horizontal axis with a vertical centerline. On the left side, four speed zones are defined by horizontal lines and labeled: 18-22.5, 22.5-27.5, 27.5-32.5, and 32.5-35. A dashed line curves from the 32.5-35 zone towards the center. On the right side, a series of horizontal lines are spaced at 10', 20', 30', 40', and 50' from the centerline. A dashed line also curves from the 32.5-35 zone towards the right. A 'MARKER BUOY' is indicated by a circle with an 'X' at the intersection of the centerline and the 32.5-35 zone. Distances of 65' and 85' are marked along the horizontal axis. A 15' distance is marked between the 32.5-35 zone and the 18-22.5 zone.

FIGURE 6 - ABYC TEST COURSE

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COAST GUARD ID NUMBER	LXB FACTOR	MANUFACTURER'S RATED HP	TESTED HP	SPEED MPH	RESULTS ¹	COMMENTS
73-01	50.5	25	25	24.8	U	Boat yaws uncontrollably in slight chop at top speed. Behavior considered dangerous.
73-05	85.6	55	40 ²	25.8	A	Marginal. Boat still has tendency to yaw at top speed in a drop.
73-07	78.3	40	40	27.3	A	Boat is very solid. Can probably handle 50 HP.
73-08	61.5	30	25	22.0	A	Marginal. Limber transom and buoyancy tubes make motor hard to control.
73-09	70.2	45	40	27.6	U	Boat well behaved, good handling characteristics.
73-10	44.2	10	10	22.3	A	Motor cavitates at offset buoy. Tendency for boat to yaw very slightly at top speed in a chop.
			25	22.3	A	Occasional problem with cavitation.
			10	19.3	U	Without optional keel, boat slides excessively in turns. Keel reduces sliding, but not enough to successfully negotiate the course. Behavior not considered dangerous.

FIGURE 7 - RESULTS OF AVOIDANCE COURSE TESTS ON SPORTBOATS

COAST GUARD ID NUMBER	LxB FACTOR	MANUFACTURER'S RATED HP	TESTED HP	SPEED MPH	RESULTS ¹	COMMENTS
73-12	49.9	18	18	24.0	U	At top speed, boat has yaw instability. Behavior considered dangerous.
73-13	115.5	65	9.8	18.8	A	Good behavior. Boat slows slightly in turns. Boat could handle more power.
			40 ³	24.4	A	Good behavior. Boat is very solid at this powering level.

NOTES:

1. U - Unacceptable. Boat fails to successfully negotiate course. } Conditions of acceptability outlined in text.
2. A - Acceptable. Boat negotiates course successfully.
3. Highest horsepower outboard available. In house 50 HP long shaft not suitable for powering this boat. Mount bracket causes water to be pumped into boat.
3. Higher horsepower motor and controls not available for testing.

FIGURE 7 - RESULTS OF AVOIDANCE COURSE TESTS ON SPORTBOATS.

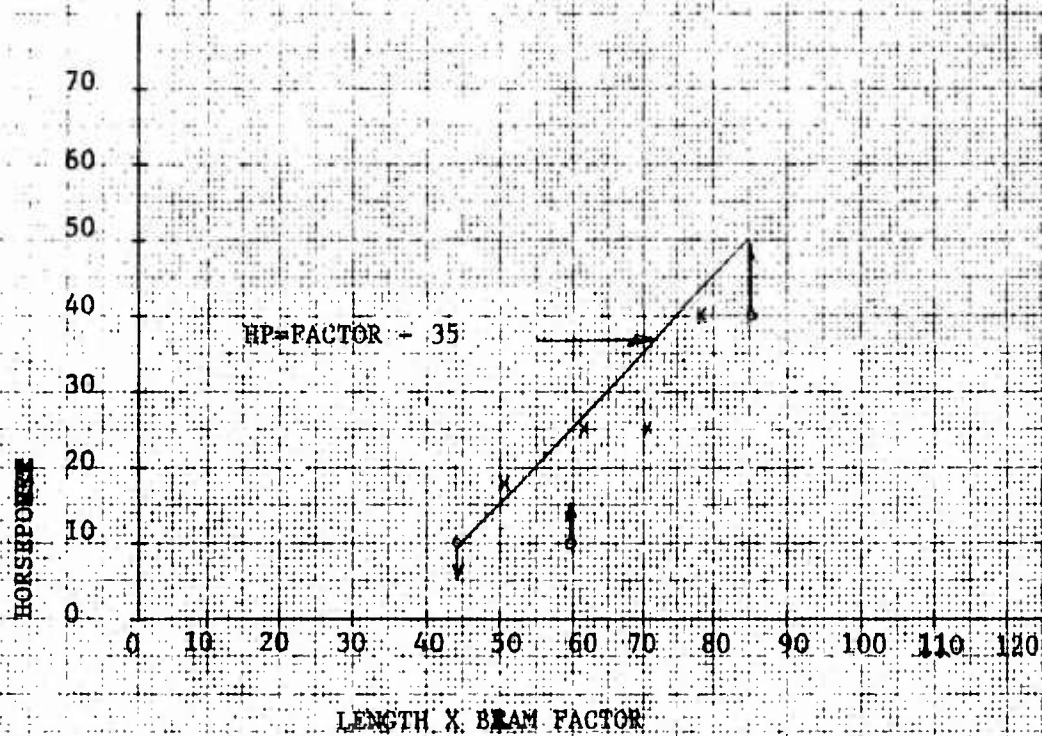


FIGURE 8 - PLOT OF AVOIDANCE COURSE HORSEPOWER VS. LENGTH/BEAM
FACTOR FOR INFLATABLE SPORTBOATS

COAST GUARD ID NUMBER	MEASURED LENGTH	MEASURED BEAM	FACTOR LxB	MAN. RATED HP	ABYC COURSE HP	SUBJECTIVE ¹ HP
73-01	10.46'	4.83'	50.5	25	18	15
73-05	14.08'	6.08'	85.6	55	40+	50
73-07	12.87'	6.08'	78.3	40	40	35
73-08	11.19'	5.50'	61.5	30	25	25
73-09	12.58'	5.58'	70.2	45	25	35
73-10	9.30'	4.75'	44.2	10	<10	7.5/10
73-12	10.33'	4.83'	49.9	18	9.8	15
73-13	16.50'	7.00'	115.5	65	Note 2	N/E

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NOTES:

1. Horsepower determined by subjective evaluation of a boat by R&DC personnel. See sec. 3.3.
 2. Appropriate motor and controls not available.
- N/E Not Evaluated.

FIGURE 9 - SUMMARY OF INFLATABLE SPORTBOAT HORSEPOWERS

4.0 CAPACITY AND FLOTATION

4.1 Objective

The objective of this task was to establish and/or evaluate various approaches to the determination of safe capacity and flotation requirements.

4.2 Preliminary Pool Tests

Preliminary capacity and stability tests were performed in the USCG Academy swimming pool. The purpose of these tests was to become familiar with and to identify any problems concerning inflatable boat behavior. The following observations were made:

4.2.1 It was difficult to ascertain specific stability limits using people as weights. Sometimes the boats would support their live load capacity on the buoyancy tubes, and sometimes not. It was found that sitting position (i.e., position of center of gravity) was critical. Further stability tests were scheduled.

4.2.2 During damage stability tests it was observed that partially inflated boats lose their shape and generally their stability characteristics. Since the boats retained their ability to support rated load it was felt that hull shape and maximum displacement were not the best measure of maximum weight capacity. Maximum weight capacities should be a function of chamber volume.

4.2.3 The boats generally had ample reserve buoyancy to support the rated load when filled with water.

4.2.4 Small amounts of added water had a tendency to increase rather than decrease the stability of a boat. This was attributed to the added mass low in the boat more than offsetting the free surface effects.

4.2.5 There was generally some sort of lateral movement in all the boats when a passenger tried to move around. The stability problem was least with the larger boats, as would be expected, and greatest with the dinghy-type boats that did not have a rigid floor.

4.3 PERSONS CAPACITY

Since buoyancy tubes and tail cone overhangs utilize a large percentage of the available space in inflatables (see Figure 11), it was felt that a passenger carrying capacity based on plan (horizontal) area would be a realistic



73-06



73-08

FIGURE 10 - PRELIMINARY POOL TESTS

Coast Guard ID Number	Actual Length	Actual Beam	Tail Cone Overhang	Passenger Area (ft ²)	LxB ₂ (ft ²)	Tail Cone Overhang Boat Length	Passenger Area LxB
73-01	10'6"	4'10"	27-3/4"	12.1	50.7	.221	.239
73-02	8'0"	4'0"	NONE	10.5	32.0	---	.328
73-03	7'5"	4'3"	NONE	7.9	31.5	---	.251
73-04	11'0"	2'10"	NONE	9.7	31.1	---	.312
73-05	14'1"	6'1"	33-1/2"	21.0	85.6	.198	.245
73-06	12'8"	4'10"	NONE	20.0	61.2	---	.327
73-07	12'10-1/2"	6'2"	13-1/2"	27.2	79.3	.087	.343
73-08	11'2-1/4"	5'7"	13-1/2"	18.7	62.4	.106	.300
73-10	9'3"	4'9"	20"	12.5	43.9	.182	.285

FIGURE 11 - DIMENSION AND AREA COMPARISONS

guideline to establish. It should be noted that this capacity rating is based on available area and not on maximum weight capacity or transverse stability. Two tests were designed to evaluate the passenger carrying ability of an inflatable boat.

In the first test, the boats were loaded with the maximum number of people they could hold inboard of the buoyancy tubes. Passengers were seated on the floor of a boat, with their knees pulled up toward their chests. The boats were overcrowded with the maximum number of people on board. There was no available space for motor, fuel, PFDS and the necessary equipment. The results are tabulated in Figure 12.

The second test was designed to find a suitable method of describing a safe loading level. Passenger capacities were calculated using the formulas $\frac{L \times B}{A}$, $A/4$, $A/5$, and $A/6$, where A was the passenger carrying area. Passenger carrying area was defined as that portion of the boat inboard of the buoyancy tubes and transom. Area under bow dodgers was excluded in the passenger carrying area. Area under removable thwarts was included in the passenger carrying area. L is the overall length and B the overall beam of the test boat. The boats were loaded and then evaluated by two observers.

The following system was used to evaluate the boats. A "1" was assigned if the boat seated the required number of passengers, but, in the judgment of the observer, lacked sufficient additional space for the operation of the boat and the carriage of necessary equipment (ie. outboard motors, fuel, PFDS). A "2" was assigned if the boat seated the required number of passengers and, in the judgment of the observer, had the minimum additional space necessary to operate the boat and carry the necessary equipment. A "2" was considered to be the lowest rating a boat could have and still be safe for use underway in actual operating conditions. A "3" was assigned if the boat seated the required number of passengers and, in the judgment of the observer, had more than sufficient additional space for the operation of the boat and the carriage of necessary equipment. A boat with a rating of "3" was not loaded to her maximum capacity, but rather to a level commensurate with optimum loading conditions.

The results of this evaluation are given in figure 13. The average passenger height and weight is given below:

No. of passengers	5	4	3	2
Average height	68"	67"	68"	69"
Average weight	155#	145#	147#	148#

Coast Guard ID No.	Max. No. Passengers	Average Height (in)	Average Weight (lbs)	Passenger Area (ft ²)	Area (ft ²) Per Passenger
73-01	4	70.5	184	12.1	3.0
73-02	3	70.0	196	10.5	3.5
73-03	2	71.0	200	7.9	4.0
73-04	4	70.5	184	9.7	2.4
73-05	8	68.5	163	21.0	2.6
73-06	7	68.3	167	20.0	2.9
73-07	8	68.5	163	27.2	3.4
73-08	6	69.7	170	18.7	3.1
73-10	5	67.6	143	12.5	2.5
	4	70.5	184	12.5	3.1

FIGURE 12 - SUMMARY OF MAXIMUM PERSONS CAPACITY TESTS

C.G. ID #	MANU. RATING	EVAL.	A/4 LOAD	EVAL.	A/5 LOAD	EVAL.	A/6 LOAD	EVAL.	LxB LOAD	EVAL.
73-01	4	1.75	3	2.50	2	3.00	2	3.00	3	2.50
73-02	3	1.75	3	1.75	2	2.50	2	2.50	2	2.50
73-03	3	1.00	2	2.00	2	2.00	1	3.00	2	2.00
73-04	2	3.00	2	3.00	2	3.00	2	3.00	2	3.00
73-05	8	----	5	2.00	4	3.00	4	3.00	6	----
73-06	5	2.00	5	1.66	4	3.00	3	3.00	4	3.00
73-07	6	2.50	7	----	5	3.00	5	3.00	5	3.00
73-08	5	2.50	4	3.00	4	3.00	3	3.00	4	3.00
73-10	4	1.50	3	2.50	3	2.50	2	3.00	3	2.50
Average Evaluation		2.00		2.30		2.77		2.94		2.69

Evaluation: 1. Boat holds people, not suitable for use.
2. Boat holds people, minimum condition.
3. Boat holds people, optimum condition.

See text, Sec. 4.3, for further details.

Listed evaluations are the averages of two independent observers.

FIGURE 13 - SUMMARY OF SAFE PERSONS CAPACITY EVALUATION

In addition to these tests, it has been suggested that a special persons capacity rule be used for dinghies such that the maximum persons capacity equals $((L \times B)1.5)/75$, where L is the overall length and B the overall beam. Only four dinghies were evaluated in the initial test program and none of these were as large as currently available dinghies. Therefore, it was necessary to extrapolate the available data in order to evaluate the $((L \times B) 1.5)/75$ formula. The safe persons capacity evaluation (Fig. 13) gives an average evaluation of 1.94 for the manufacturers' recommended capacities on dinghies 73-02, 73-03, 73-04, and 73-06. This average comes very close to the minimum acceptable evaluation of 2.0 and therefore it was assured that the manufacturer's recommended capacity for a dinghy would be the maximum safe rating if evaluated according to the maximum persons capacity test. Manufacturers' ratings for 14 sample boats are given below.

SAMPLE NO.	LxB FACTOR	MANUFACTURERS RECOMMENDED NO. OF PERSONS
1	41.9	2
2	46.7	3
3	51.6	4
4	61.2	5
5	32.0	2/3
6	39.0	4/5
7	46.7	5/6
8	64.0	7
9	84.5	7/8
10	105.0	8/10
11	36.0	3
12	40.5	4
13	45.0	5
14	54.0	6

Figure 14 is a plot of the manufacturer's recommended capacity, the $(LxB)^{1.5}/75$ capacity, and the A/4 capacity. Manufacturer's capacities are shown as "X." Capacities given as a range of numbers are shown as "X" connected by a straight line. Points used to plot the A/4 curve are shown as circles.

While the agreement is good between the proposed $(LxB)^{1.5}/75$ capacity and the manufacturer's capacities up to LxB equal to 70, the proposed capacity seems to be too great for higher LxB factors. For the largest dinghy currently available ($L=15'$, $B=7'$, $LxB=105$) the proposal allows a maximum persons capacity of 14. The manufacturer recommends 8 to 10. Therefore the proposal gives a 60 to 75 percent increase over the assumed safe persons capacity. For this reason the proposal is considered unacceptable for the larger dinghies.

Agreement between the A/4 capacity and the manufacturer's capacities follows the same trend as $(LxB)^{1.5}/75$, but the discrepancy for the higher LxB factors is only 10 to 38 percent over the assumed safe persons capacity.

Figure 15 is a comparison of the persons capacity methods. It is felt that an "A/4" factor gives a safe persons capacity without being restrictive since it gives an average evaluation closest to the minimum acceptable value of "2." It is also felt that a passenger capacity based on "A" (passenger carrying area) is better than one based on overall dimensions (LxB). Under a passenger capacity based on overall dimensions, a boat could be designed with abnormally large diameter buoyancy tubes to increase maximum weight capacity and the actual area available for carrying passengers would be small. With a passenger capacity based on passenger carrying area and a maximum weight capacity based on chamber volume a designer is encouraged to optimize boat habitability and weight carrying capacity to arrive at a safe design.

4.4 LIVE LOAD CAPACITY

The lack of seats and general configuration of most inflatable boats encourages passengers to sit on the buoyancy tubes during some phases of operation. This was especially true in inflatable sport boats. Two different tests were performed to evaluate transverse stability under this loading condition.

The first set of tests was done during the preliminary pool tests (see Section 4.2). In this set of tests people seated on the buoyancy tubes were used as off-center weights. No counterbalancing centerline weights were used. Because of the difficulty in positioning the center of gravity when using people as weights, there was generally a range of weights for which capsizing would occur. The minimum and maximum weights are given below for the eight boats in house at that time.

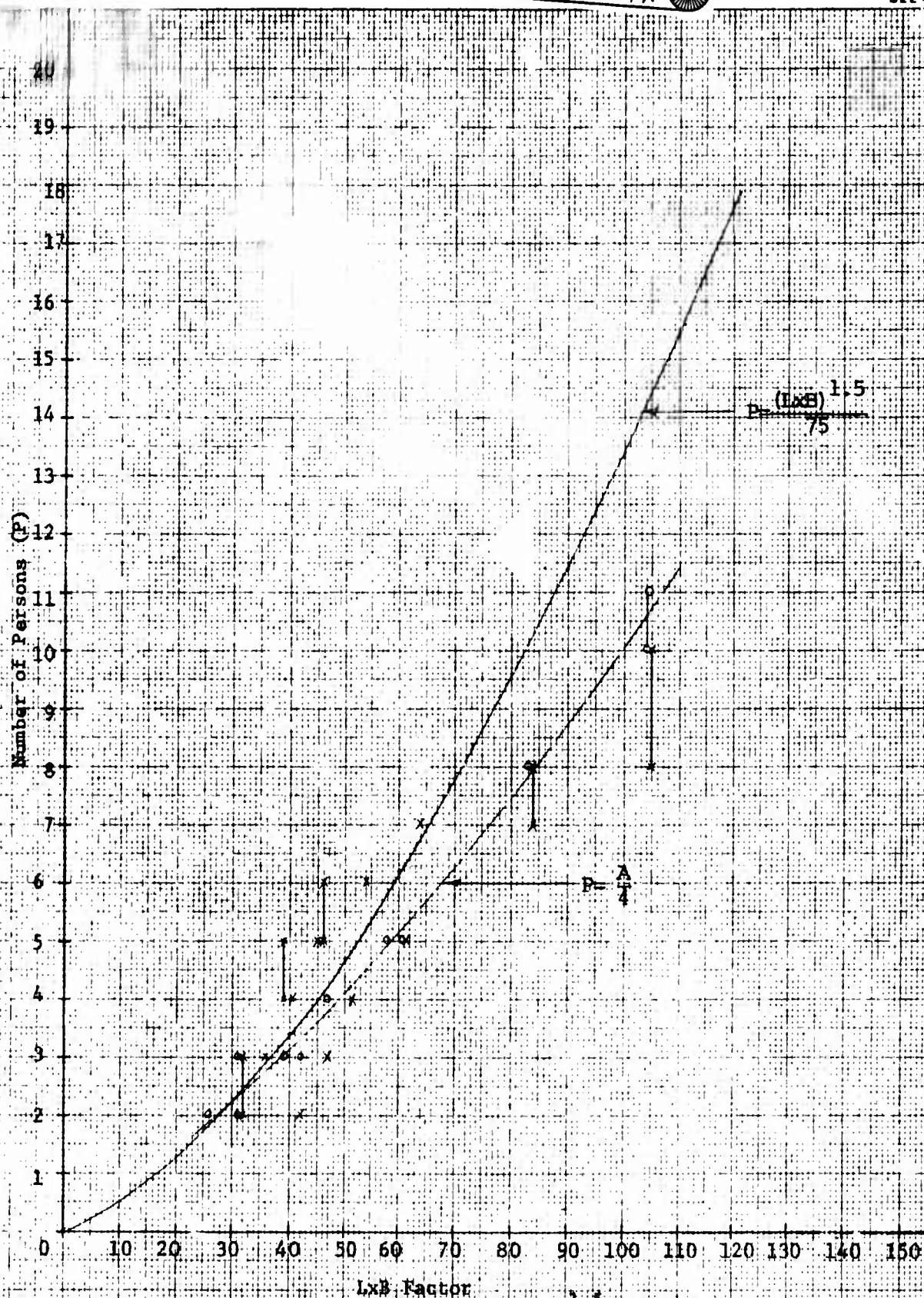


Figure 14 - Plot of persons capacity ($\frac{(LxB)^{1.5}}{75}$ and $\frac{A}{4}$) and manufacturer's recommended persons capacity vs length/beam factor.

Coast Guard ID Number	(Col.1) Maximum Persons Capacity (from Fig. 9)	(Col.2) Manufacturers Rating	(Col.3) LxB/15 Capacity	(Col.4) A/4 Capacity	(Col.5) $\frac{\text{Col. 1}}{\text{Col. 4}}$	(Col.6) $\frac{\text{Col. 2}}{\text{Col. 4}}$	(Col.7) $\frac{\text{Col. 3}}{\text{Col. 4}}$	Average 1/3 (Col.5+Col.6+Col.7)
73-01	4	4	3	3	1.33	1.33	1.00	1.22
73-02	3	3	2	3	1.00	1.00	.67	.89
73-03	2	3	2	2	1.00	1.50	1.00	1.17
73-04	4	2	2	2	2.00	1.00	1.00	1.33
73-05	8	8	6	5	1.60	1.60	1.20	1.47
73-06	7	5	4	5	1.40	1.40	.80	1.20
73-07	8	6	5	7	1.14	0.86	.71	.90
73-08	6	5	4	4	1.50	1.25	1.00	1.25
73-10	5	4	3	3	1.67	1.33	1.00	1.33
				Average		1.40	.93	1.20

FIGURE 15 - COMPARISON OF PERSONS CAPACITY METHODS

CG ID Number	Minimum Persons Weight	Maximum Persons Weight
73-01	314 #	653 #
73-02	367 #	Same as minimum persons weight
73-03	332 #	339 #
73-04	350 #	528 #
73-05	898 #	1049 #
73-06	494 #	815 #
73-07	993 #	1056 #
73-08	838 #	993#

In the second test, the rated horsepower outboard was mounted on the transom and the battery and fuel tank weights as given in the Federal Register, Vol. 37, No. 151, Part II, were placed on the boat centerline, where applicable. The boats were then loaded with lead weights on the centerline of the buoyancy tubes. To find live load capacity, the weight on the buoyancy tubes was divided by 0.60, in accordance with the procedure outlined in the Federal Register, Vol. 37, No. 151, Part II. Since outboard motor brackets for dinghies are an option, these boats were tested without outboards and auxiliary equipment.

Five boats characteristic of the complete range of dinghies and sportboats were tested. The results are as follows:

CG ID Number	Capsizing Load	Live Load Capacity
73-02	121.25 #	203 #
73-06	173.75 #	290 #
73-07	659.25 #	1099 #
73-08	490.50#	817 #
73-10	384.75 #	641 #

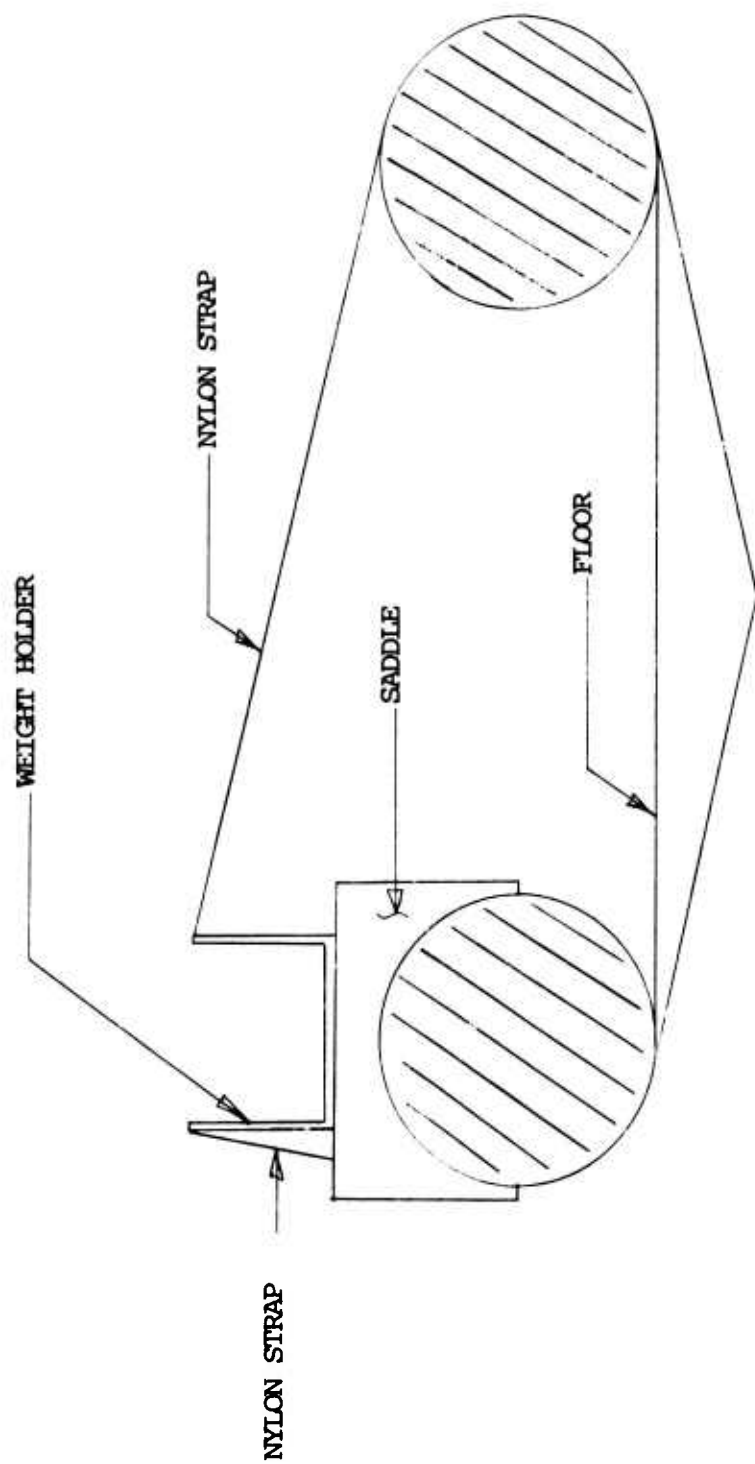
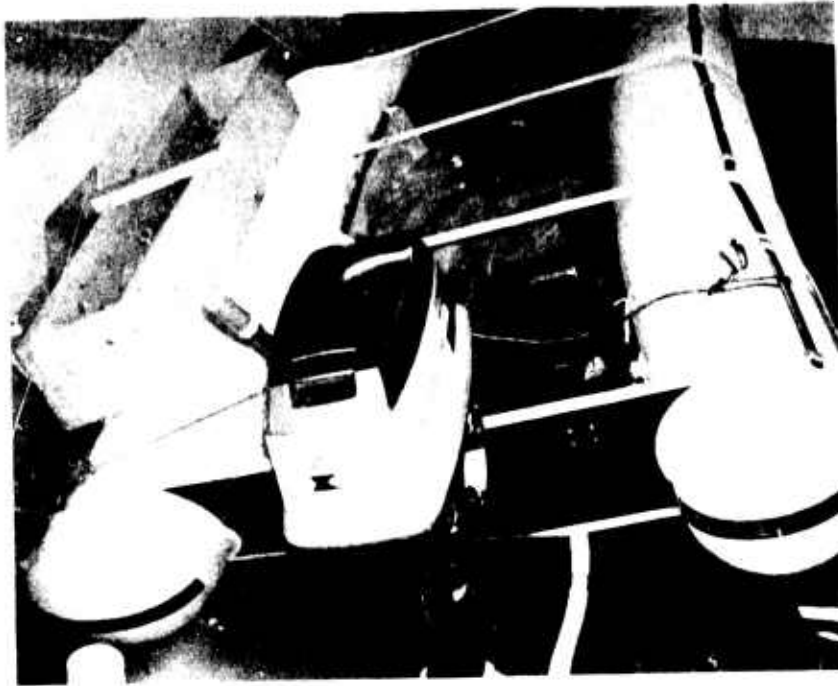


FIGURE 16 - DIAGRAMATIC SKETCH OF LIVE LOAD TEST EQUIPMENT



73-07



73-10

FIGURE 17 - LIVE LOAD TESTING

The preliminary pool tests with people indicate that buoyancy tube loading with concentrated weight might not be representative of an actual live load. Since the live load capacities, persons capacities, and persons' weights agree favorably, it is felt that a live load capacity for inflatable boats is unnecessary.

4.5 MAXIMUM WEIGHT CAPACITY

Preliminary pool testing (Section 4.2) indicated that the weight capacity should be a function of inflated chamber volume. This approach is also followed by the French and British inflatable boat specifications. Chamber volumes were calculated for several sample boats using basic geometry. Maximum weight capacities were calculated using three different formulas:

$$\text{Capacity} = .75 D_C - W$$

$$\text{Capacity} = .60 D_C - W$$

$$\text{Capacity} = .50 D_C - W$$

where:

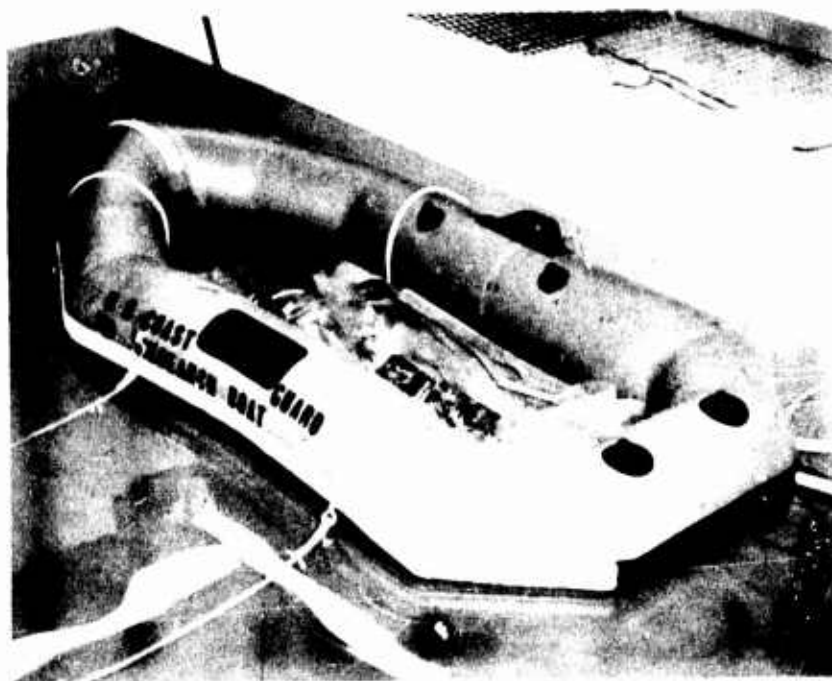
D_C = Main Chamber Volume. Excludes removable chambers.
Expressed in pounds of displaced fresh water.

W = Weight of the boat hull, floorboards and all its permanent appurtenances. Outboard motors are not included.

The $0.75 D_C - W$ formula is used in the British and French specifications; $0.50 D_C - W$ gives capacities similar to those given by the formula for conventional outboard boats (maximum displacement - boat weight); $0.60 D_C - W$ was taken as an average between the two. ⁵ Figure 19 is a comparison of the capacities derived from these three formula.

Testing in the R&D Center test tank was performed using lead weights. In most cases the capacity given by $0.75 D_C - W$ was judged to be too great. This amount of weight caused deflection in the buoyancy tubes both in the profile and waterline planes, on the order of magnitude of two to three inches. Freeboard was reduced by an average of 38% for sportboats and 23% for dinghies with this amount of weight. The remaining freeboard was considered to be inadequate.

Capacities calculated from the $0.50 D_C - W$ formula were acceptable. Freeboards were reduced by an average of 28% for sportboats and 15% for dinghies. It was felt that the boats could handle more weight than that allowed by this formula.



73-02

FIGURE 18 - MAXIMUM WEIGHT CAPACITY TEST

COAST GUARD ID NUMBER	TOTAL BUOYANCY (LBS)	BOAT WEIGHT (LBS)	MAXIMUM WEIGHT CAPACITY		
			.75 D _C -W (LBS)	.60 D _C -W (LBS)	.50 D _C -W (LBS)
73-01	1463	106	991	772	626
73-02	854	53	588	459	374
73-05	3024	220	2048	1594	1292
73-06	1702	48	1229	973	803
73-07	2618	165	1799	1406	1144
73-08	1664	115	1133	883	717
73-10	1132	89	760	590	477

FIGURE 19 - COMPARISON OF MAXIMUM WEIGHT CAPACITIES

Tests of the $0.60D_G - W$ criterion showed a decrease in freeboard of 34% for sportboats and 19% for dinghies. These freeboards were considered to be acceptable, and it was felt that this formula gave the safest compromise between available freeboard and maximum weight capacity.

During these tests it was noted that the non-rigid fabric floors of the dinghies distended considerably when loaded with weight. This increased their displacement considerably with only a small decrease in freeboard. This is the reason for the difference in the percentage decreases in freeboard between the sportboats and the dinghies.

5.0 MATERIALS AND FABRICATION TECHNIQUES

5.1 Objective

The objective of this program was to establish and/or evaluate methods of determining the adequacy of materials, construction techniques, and construction details as they relate to the safety of inflatable boats.

5.2 Inflation Tests

Inflation tests are a simple and effective method of evaluating the structural integrity of inflatable boats. Three tests have been suggested during industry (American Boat & Yacht Council) meetings to develop a standard. They are:

- a. Over-pressure test.
- b. Working pressure test.
- c. Bulkhead integrity test.

5.1.1 Over-Pressure Test - In the over-pressure test, the entire boat is to be inflated to 2.5 times the manufacturer's recommended working pressure. Manufacturers generally agreed that inflation to this pressure is a good test of the overall strength of the hull fabric and seams. Working stresses arising from powering and general boat usage were felt to be well within this limit.

As an example, if a PVC dinghy with a normal working pressure of 1.0 psig were inflated on a cool 40° F morning, it would be necessary for afternoon temperatures to exceed approximately 88° F in order to increase inflation pressure by 2.5 times. If a sportboat with normal working pressure of 4.0 psig were subjected to similar conditions, afternoon temperatures would have to exceed 200°F in order to increase inflation pressure by 2.5 times.

5.2.2 Working Pressure Test - The working pressure test is designed to measure the air seepage from a boat. It is a test of the quality of the construction of the boat. The proposed industry standard calls for a pressure drop of not more than 20% in a 24 hour period. Some manufacturers feel that this requirement may be too stringent. They maintain that an inflatable boat can experience a considerable pressure drop without affecting the buoyancy necessary to float passengers and equipment. This is true, but most inflatable boats also derive the rigidity necessary to safely handle an outboard motor from inflation

Coast Guard ID Number	Over-Pressure & Loss	Working Pressure ¹ & Loss		Bulkhead Integrity & Loss		
		Group 1	Group 2	Chamber 1	Chamber 2	Chamber 3
73-02	.5%	6.8%	Not Applicable	0.0%	0.0%	Not Applicable
73-03	Failure	-----	-----	-----	-----	-----
73-10	.3%	10.4%	Not Applicable	1.6%	1.6%	0.0%
73-11	.8%	9.0%	16.3%	Not Applicable	Not Applicable	Not Applicable
73-12	.4%	4.9%	Not Applicable	3.3%	2.0%	Not Applicable

36

1 - Due to physical limitations of pressure manifold, it is sometimes necessary to conduct tests in groups of chambers.

FIGURE 20 - SUMMARY OF INFLATION TESTS

pressure. Since some inflatable boats barely have sufficient rigidity to handle outboards motors when correctly inflated (73-06, 73-07, fig. 4), it is felt that the loss of pressure due to leakage should be kept small. Pressure tests on several sample boats (fig. 20) indicate that a 20% pressure drop is well within the limits of current technology.

5.2.3 Bulkhead Integrity Test - The purpose of the bulkhead integrity test is to insure the proper construction and installation of the membranes separating air compartments, thereby insuring compartment isolation in the event of damage. With adjacent compartments open to the atmosphere, a compartment is inflated to 1.5 times the recommended working pressure. Manufacturers feel that this pressure is sufficient because of the difficulty involved in making internal seams. During inflation testing it was noticed that when an adjacent compartment is deflated, the dividing bulkhead between it and intact compartments distends. This increases the volume of the intact compartment, and actually leads to a decrease in compartment pressure. Therefore 1.5 times the recommended working pressure is considered to be a safe working factor to test bulkheads to, since it is unlikely that the pressure in one compartment would ever exceed 1.5 times the working pressure following the failure of an adjacent compartment.

6.0 HUMAN FACTORS

6.1 Objective

The objective of this program was to identify, evaluate, and develop criteria for those human factor elements (if any) which should be included in a Federal safety standard.

6.2 Observations

The following observations have been made concerning human factors influences on inflatable boats:

6.2.1. Control Arrangement and Position - Three boats were ordered with optional remote controls. These are 73-05, 73-08 and 73-09. The steering wheel and controls of 73-05 were rigidly mounted in a suitable position, but the inflatable seat supplied was unsuitable for properly locating and restraining the operator.

The seats on 73-08 broke in moderate swells (approx. 1 foot). The fastenings securing both seats' back/bottom hinge pulled out. In addition the operator's seat bottom broke. Operator weight was 195 lbs., passenger weight 180 lbs. The seat did not properly locate and restrain the operator and during maneuvers he slid from side to side. The controls were arranged such that the operator's legs obstructed the throttle and gear changing levers and hindered the movement of the steering wheel. The steering and controls on 73-09 were rigidly mounted, but the securing bolts and wing nuts used could easily cause injury. No seat was purchased with 73-09.

6.2.2 Swimmer Boarding - Preliminary pool tests in the Coast Guard Academy pool indicate that the boats were generally stable when being boarded by a swimmer, even when he was assisted by another passenger reaching over the side. There was some difficulty boarding the larger boats because of their greater freeboard.

7.0 CONCLUSIONS

7.1 Standards

Based on the results of experimental testing and subjective evaluation of inflatable boats as previously described, standard concepts for possible inclusion is a Federal Safety Standard for inflatable boats would include:

7.1.1 Label Plate - The following minimum information should be permanently affixed and displayed in a prominent location in the boat.

- a. Maximum horsepower.
- b. Maximum weight capacity (persons, motor & gear) in pounds.
- c. Maximum persons capacity.
- d. Recommended inflation pressure.
- e. Name of manufacturer.

7.1.2 Instructions - The manufacturer should provide instructions, in English, containing the following minimum information:

- a. Limitation and intention of use.
- b. Assembly and inflation instructions.
- c. Repair instructions.
- d. Recommended equipment.
- e. Method of determining correct inflation pressure, in lieu of supplying a pressure gauge.

7.1.3 Maximum Horsepower Capacity - The following upper limits for horsepower ratings is suggested:

7.1.3.1 For boats with detachable motor mounts, 4 hp maximum

7.1.3.2 For boats with transoms, a factor approach is suggested:

a. Factor = Boat Length (feet) x Beam (feet)
(to nearest whole number)

b. For boats without remote steering:

<u>Factor Range</u>	<u>Horsepower Formula</u>
45-60	HP = Factor - 35
60-85	HP = 25
86-115	HP = 40

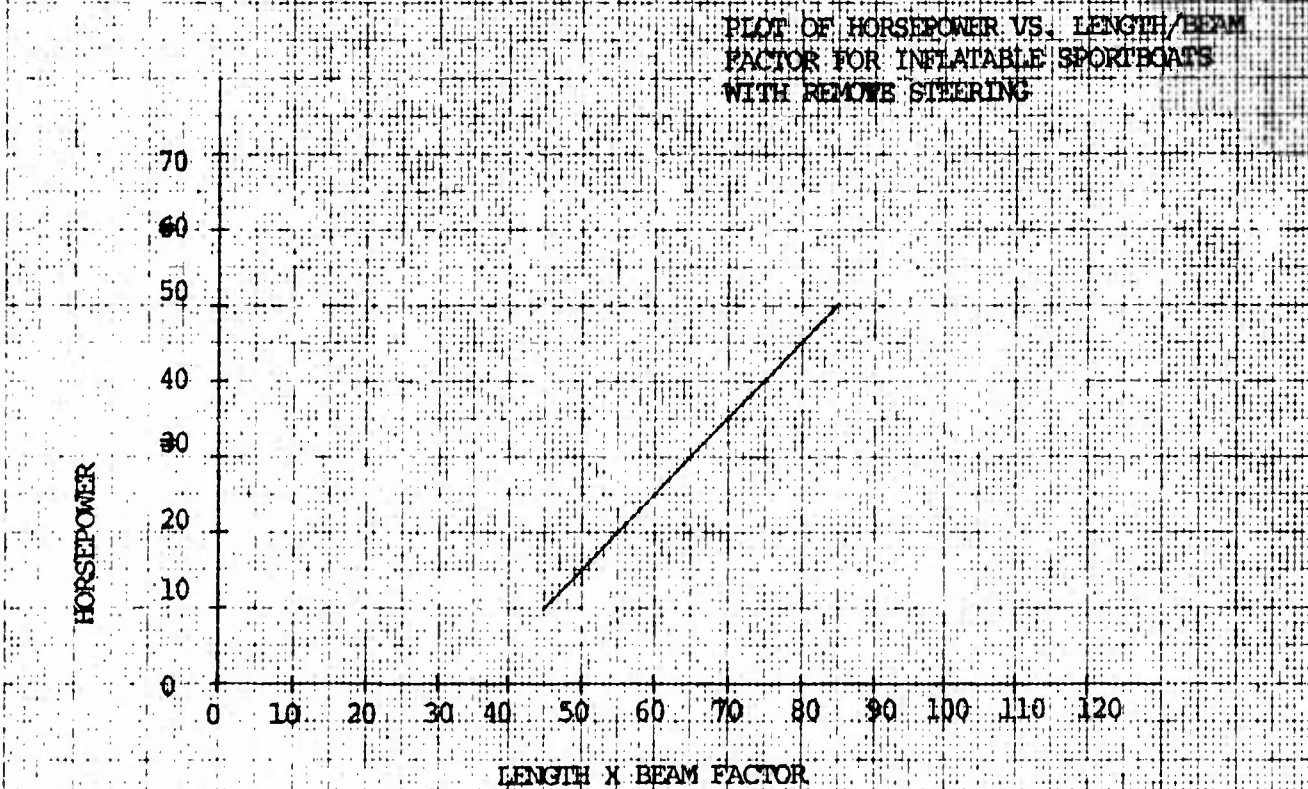
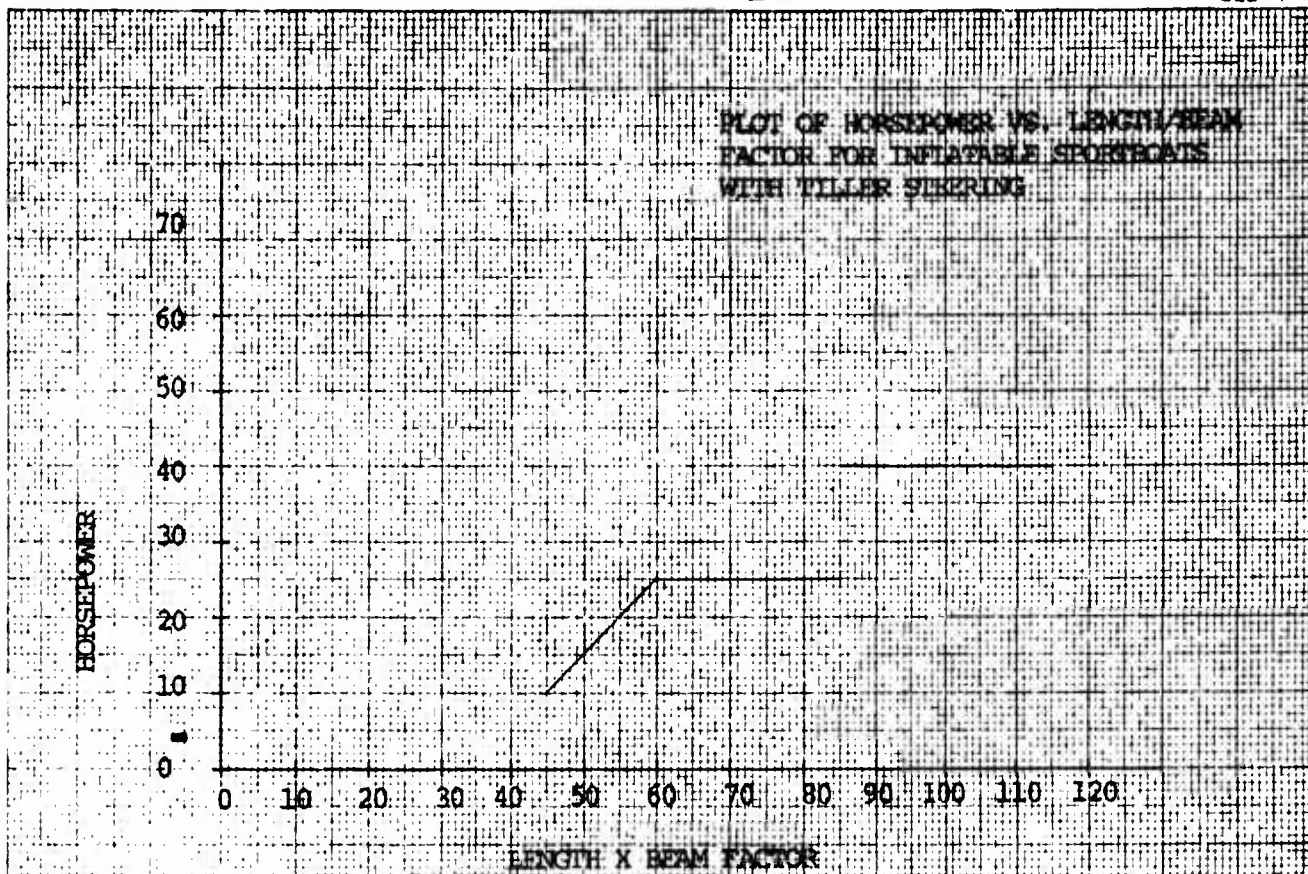


FIGURE 21 - POWERING FORMULAS FOR INFLATABLE SPORTBOATS

c. For boats with remote steering:

<u>Factor Range</u>	<u>Horsepower Formula</u>
45-85	HP = Factor - 35

7.1.3.3 Discussion - The strength of the motor attachment in an inflatable boat is a critical factor in determining safe horsepower ratings. While the above recommendations may seem conservative with respect to boat performance, they are necessary because of the weakness in some inflatable boat transoms (eg. figure 4, 73-06,73-07).

Yaw instability at speed is an additional factor in determining safe horsepower ratings. Of eight sportboats tested, three had a problem with yaw instability at higher speeds and horsepowers (figure 7).

Subjective evaluation indicates the 25 horsepower is a good upper limit for manually controlled motors on most boats. All operators agreed that the tiller forces required to control the torque of a 25 horsepower motor were reasonable, even at top speed. It is recognized however that large boats with heavy loads may require more horsepower, but still require tiller control. It is felt that boats with factors over 85 are large enough to provide a stable platform for controlling the increased torque of a 40 horsepower outboard. However, it should be noted that, even with large boats, operators found a manually controlled, 40 horsepower motor difficult and tiring to handle. It is also felt that this is a facet of the powering problem that is not peculiar to inflatable boats.

7.1.4 Maximum Weight Capacity - The following formula describes a suggested upper limit for the maximum weight capacity:

$$\text{Maximum weight capacity} = .6D_c - W$$

where:

D_c = Main buoyancy chamber displacement. This excludes the displacement of all removable chambers. Displacement is expressed in pounds of fresh water.

W = Boat weight. Weight of the boat hull, floorboards and all its permanent appurtenances, excluding motor.

7.1.5 Maximum Persons Capacity - It is suggested that the upper limit of persons capacity should not exceed the number given by a or b, whichever is smaller:

- a. Passenger carrying area (A) divided by 4. Where A is defined as that horizontal area of the boat (in square

feet) inboard of the buoyancy tubes and transom. Area under bow dodgers is to be excluded from A. Results of calculations should be rounded to the nearest whole number.

- b. The maximum weight capacity divided by 150. Results of calculations should be rounded to the nearest whole number.

7.1.5.1 Discussion -

The characteristics of an inflatable boat are such that two requirements must be met in determining maximum persons capacity. An inflatable boat must have enough available space to safely accommodate its passengers and, enough buoyancy to support its passengers' weight. It was shown in section 4.4 that transverse stability was not a consideration in inflatable boat passenger capacity for the boats tested.

Maximum weight capacity divided by 150 (b above) is designed to a persons capacity based on weight carrying ability.

There are two methods for determining the available space to safely accommodate passengers. One is based on passenger carrying area (A) and the other on a length times beam factor ($L \times B$).

An approach based on "A" was chosen because it is an actual measure of the available space. An " $L \times B$ " factor is only an indicator of the available area. The relation between " $L \times B$ " and "A" is affected by boat proportions, tail cone overhang and buoyancy tube diameter. Under a passenger capacity based on overall dimensions ($L \times B$), a given sized boat could be designed with large diameter buoyancy tubes to increase maximum weight capacity and the actual area available for carrying passengers would be small. With a passenger area (A) a designer is encouraged to optimize boat habitability and weight carrying capacity to arrive at a safe design.

The factor $A/4$ (a above) was chosen to determine the space available to safely accommodate passengers (see section 4.3). The area under bow dodgers is excluded since it is usually fairly small when compared to total passenger area.

7.1.6 Compartmentation - It is felt that inflatable boats should be constructed so that there are at least two individual air compartments within the hull, excluding detachable inflated the other will retain its integrity. The boat should be capable of supporting 80% of the rated load (see section 7.1.4) with the largest compartment deflated. This requirement insures compartments of almost equal size.

It should be noted that the proposed industry standard requires three separate chambers for boats 12 feet in length and over two separate chambers for boats under 12 feet in length.

7.1.7 Pressure Retention - When new, inflatable boats with all aire compartments inflated to the manufacturer's recommended working pressure should not lose more than 20% of this pressure over 24 hours of inflation. Appropriate corrections shall be made for changes in temperature and/or barometric pressure.

7.1.8 Compartment Strength - Each compartment should withstand a minimum of 1.5 times the manufacturer's suggested working pressure for 30 minutes with the adjacent compartment at atmospheric pressure. No evidence of failure should occur.

7.1.9 Boat Strength - When new, inflatable boats shall be able to withstand a minimum pressure of 2-1/2 times the manufacturer's suggested working pressure for ten minutes. No evidence of failure should occur.

7.1.10 Motor Attachment - The transom or motor mount and its attachments to the boat should be designed to withstand the maximum stresses arising from:

- a. The forward and reverse thrust of the motor(s) representing the maximum horsepower capacity of the boat.
- b. The weight of such motor(s).

7.1.11 Marine Environment Compatability - All materials used in the construction of an inflatable boat should be resistant to salt water, fresh water, sunlight and exposure to motor fuels.

7.2 Standards Comparison

The following table is a basic comparison of the existing French and British Specification, the proposed draft of the ABYC Standard, and the R&D Center conclusions.

8.0 PROPOSED FUTURE WORK

8.1 Materials and Fabrication Techniques

A deeper investigation of material properties (tear strength, tensile strength, abrasion resistance, etc.) is planned to determine what parameters, if any, should be included in a Federal standard.

8.2 Vinyl Boats

Work done to date has centered mainly on the more expensive, coated nylon boats. Further experience with the inflatable boat market indicates that that the inexpensive, unsupported vinyl boats are receiving most of the attention and exposure. Therefore, further work on these inexpensive boats may be justified.

COMPARISON OF EXISTING STANDARDS
PROPOSED STANDARDS & R&DC CONCLUSIONS

BRITISH STANDARD	FRENCH STANDARD	PROPOSED DRAFT OF ABYC STANDARD	CG R&DC
<p>Label Plate</p> <p>1-Name of Manufacturer 2-Date of Manufacture or serial number 3-Maximum load capacity 4-No. of applicable British Standard 5-Maximum rec. HP</p>	<p>1-Name of Manufacturer 2-Type of Boat 3-Series No. 4-Series No. 5-Year of Manufacture 6-Rec. HP</p>	<p>1-Maximum HP 2-Maximum weight capacity 3-Maximum persons 4-Working pressure (on boat, but not necessarily on plate)</p>	<p>1-Maximum HP 2-Maximum weight capacity 3-Maximum persons 4-Rec. inflation pressure 5-Name of Manu- facturer</p>
<p>Required Equipment</p> <p>1-Bellows 2-Pair of oars or paddles 3-Repair kit 4-Manual of instructions</p>		<p>1-Instruction manual</p>	<p>1-Instruction manual</p>
<p>Information to be included in instructions</p> <p>1-Rec. pressure</p>		<p>1-Safe operation 2-Assembly 3-Repair 4-Rec.equipment 5-Limitation & intention of use</p>	<p>1-Limitation & intention of usage 2-Assembly & inflation 3-Repair 4-Rec.equipment 5-Method of determining correct pressure</p>
<p>Powering</p> <p>Subjective evaluation of boat on prescribed headings under pre- scribed conditions</p>	<p>Boat is rated by manufacturer. No guidelines.</p>	<p>Boats w/motor bkts: Less than & incl. 10' - 5 HP Over 10' - 7.5 HP Boats w/transoms: LxB factor method 0-42 HP= 7.5 42-80 HP=(10/9XF)-40 over 80HP=(1/2XF)+10</p>	<p>Boats w/motor bkts: HP=4 Boats w/transoms: LxB factor method Boats w/o Remote Steering: 45-60 HP=Factor-35 85-115 HP=40</p>

BRITISH STANDARD FRENCH STANDARD PROPOSED DRAFT OF ABYC STANDARD CG R&DC

				Rec. remote controls over 25 HP Ratings subject to testing.	Boats w/Remote Steering: 45-85HP=Factor-35
Maximum weight capacity	.75 D _C -W D _C = Volume of permanently attached chambers	≈ .75 D _C ; some additional buoyancy calculations are req'd.		.60 D _C -W W= Boat Weight	.60 D _C -W
Persons Capacity	Max. - Load of max. load rec. motor & fuel 165	Least of: 1 Usable passenger area (incl.dodger) ÷ 3.23 2 Buoyancy reserve (total chamber cap. less vol. main chamber) ÷ 88 (lbs.) 3 Max. capacity ÷ 165 lbs.	Least of: 1 Usable passenger area (incl.dodger) ÷ 4 2 Max. wt. capacity ÷ 165	Least of: 1 Usable passenger area (excl.dodger) ÷ 2 2 Max. wt. capacity ÷ 150	

	BRITISH SPECIFICATION	FRENCH SPECIFICATION	PROPOSED DRAFT OF ABYC STANDARD	CG R&DC						
Compartmentation	<p>No. req'd chambers:</p> <table><tr><td>Up to & incl 9 HP</td><td>Over 9 HP</td></tr><tr><td>Up to & incl 15'</td><td>2</td></tr><tr><td>Over 15'</td><td>3</td></tr></table> <p>Chamber volumes (V_C) as a function of boat volume (V_b) & No. of chambers (n):</p> $V = \frac{V_b}{c \cdot n} \times (1 \pm 0.20)$	Up to & incl 9 HP	Over 9 HP	Up to & incl 15'	2	Over 15'	3		<p>Boats under 12' -- 2 chambers</p> <p>Boats over & incl. 12'--3 chambers</p> <p>Boats should be capable of supporting 75% of max. wt. with largest compartment deflated</p>	<p>Minimum of 2 chambers</p> <p>Boat should be capable of supporting 80% of max. wt. with largest compartment deflated.</p>
Up to & incl 9 HP	Over 9 HP									
Up to & incl 15'	2									
Over 15'	3									
Strength	<p>1-Comprehensive laboratory tests.</p> <p>2-Pressure loss individual compartment--2% in 15 minutes; boats--20% in 24 hrs</p>	<p>1-Comprehensive laboratory tests & specs.</p> <p>2- Pressure loss --30 mb in 100 mb in 24 hrs</p> <p>3-Compartments must withstand 1.5X Normal pressure for 30 min.</p>	<p>1-Material compatability w/marine environment.</p> <p>2-Pressure loss for boat 20% in 24 hrs</p> <p>3-Compartment strength 1.5X normal working press. for 30 min.</p> <p>4-Boat strength-2.5X working press. for 10 min.</p>	<p>1-Material compatability w/marine environment</p> <p>2-Pressure loss for boat 20% in 24 hrs.</p> <p>3-Compartment strength-1.5xrec working press. for 30 min.</p> <p>4-Boat strength - 2.5 x rec. working press. for 10 min.</p>						

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NOTE: Metric units in foreign standards have been converted to English units for comparison purposes.

9.0 DEFINITIONS

Maximum Weight Capacity - The maximum allowable load, in pounds, for persons, motor and gear.

Live Load Capacity - The live load (passenger weight), in pounds, based on the transverse stability of the boat.

Persons Capacity - The allowable number of passengers, based on the usable passenger carrying area. This number is an index of boat habitability and not of hydrostatic characteristics.

LIST OF REFERENCES

1. British Standard Marine Series Specification for Inflatable Boats, British Standards Institution
2. Adopted Specification Project for Pneumatic Boats, Naval Engineering and Industries Pleasure Navigation
3. Recommended Practices and Standards Covering Inflatable Boats, American Boat and Yacht Council, Inc.
4. Safety Standards for Small Craft, American Boat and Yacht Council, Inc.
5. Federal Boat Safety Act of 1971, Public Law 92-75
6. Federal Register, Vol. 37, Number 151, Part II